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(No. 1 is an introductory and explanatory number.)

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Name of Disease: Potato wart, potato canker or cancer, black scab, cauliflower, warty disease.

Name of Pathogen: Synchytrium endobioticum (Schilb.) Perc.
Syn. Chrysophlyctis endobiotica Schilb.

Hosts: Hyoscyamus niger, Lycopersicum esculentum, Nycandra physalodes, Solanum alatum, S. album, S. chacoense, S. commersoni, S. dulcamara, S. jamesii, S. nodiflorum, S. tuberosum, S. villosissimum, S. villosum, and by inoculation Datura inermis, D. metel, Physalis francheti, Schizanthus pinnatus, Solanum atropurpureum, S. marginatus, S. miniatum, S. miniatum rubricaulle, S. miniatum viridicaule, S. niger, S. nigrum macrocarpum, S. nigrum chlorocarpum, S. racemigerum.

Ducomet and Diehl (7) state that a study of tuberiferous species of Solanum showed that types susceptible to wart are present in all chromosome types. (1, 8, 15, 21)

Part attacked: On potato the tubers are particularly susceptible, infection being through the eyes usually, but all underground parts of hosts are susceptible. Leaves and stems become infected also at times on potato at least. (13)

Place of origin: South America.

Country of first report: Hungary, 1896. (The part of Hungary involved later became part of Czechoslovakia)

It is said the disease cannot be found now in the area from which Schiltersky first reported it. The disease appears to have been in England (1, 4) at the time it was first reported.

First report from the U. S.: Pennsylvania, Sept. 1918.

Present distribution: Algeria, Austria, Belgium, Bolivia, Canada, Czechoslovakia, Danzig Free State, Denmark, England, Faroe Islands, Finland, France, Germany, Ireland, Japan, Malta (said to have been eradicated but see (16)), Miquelon Island, Newfoundland, Peru, Poland (in an area formerly part of Germany), Portugal, Rumania, Scotland, Spain, St. Pierre, Sweden, Switzerland, Union of South Africa, United States, Wales. It has been reported from Russia, apparently in error. (19)

Factors affecting severity: Susceptibility of host is the most important factor. Wart is said to be confined to areas with growing seasons of 140 days or less. Soils with temperatures of 60° to 64° F. are said to favor development of wart and with temperatures of 70° to 72° F. to inhibit development. Periodic flooding of soils followed by drainage and aeration favors development of wart. (2, 10, 11, 16)

Methods of spread: Any agency that will distribute soil, tubers or other plant parts containing or bearing spores, including drainage water, farm implements, men, animals, diseased tubers, tubers with adhering spores, manure from animals fed diseased tubers, garbage, etc. Local spread seems to be especially prevalent in areas of dense population with small holdings. Long distance spread is most likely to occur with potato tubers in the form of adhering spores or inconspicuous lesions. (6, 8, 10, 22)

Losses incurred: In Finland as a whole the average loss due to wart, on infected land, was 7.4%. In Austria and in England planting of a susceptible variety in contaminated soil has been known to result in practically a total loss of crop. (1, 10, 18)

Comparative losses: Strict state quarantine measures and the use of immune varieties has prevented determination of possible crop losses in this country. Where a prompt change to resistant varieties is made, little direct loss results, though the substitute variety may yield less and be of less desirable quality.

Control methods: Quarantines and use of immune or highly resistant varieties are the usual control measures. The use of fungicides is not profitable in general. Continuous growing of cultivated non-susceptible crops makes possible planting of potatoes once in eight years without serious losses.

Where the infected area is small, eradication by slow starvation or by treatment of the soil with chemicals may be profitable. (2, 10, 12)

Quarantine action: Section 7 of the plant quarantine act of August 20, 1912, provides that the quarantine provisions of this section, as applying to potato wart, shall become and be effective upon passage of the act. Under this provision the Potato Wart Quarantine No. 3 was signed September 20, 1912 (issued September 28, 1912), effective immediately. More recently the entry of potatoes has been governed by the potato regulations which were originally issued December 22, 1913, and since revised or amended several times. These regulations are based on potato wart primarily.

Description: On susceptible varieties of potato the disease is characterized by wart-like outgrowths on the tubers or replacing tubers at the end of stolons. These "warts" are more commonly developed from the eyes of tubers, less often on stolons or bases of stems. The warts are whitish at first but turn black and often become watery as they get older. When exposed to light at the ground surface, warts are green. Warts may be extremely small or may be larger than the tubers on which they are borne.

On resistant varieties of potatoes infected cells may turn brown and fleck off without producing spores and when sori mature, they may be difficult to find even when examined with extreme care. Such infections could not be found with certainty by inspection methods applicable to commercial shipments or even to small lots of potatoes.

In structure S. endobioticum is a very simple fungus, without mycelium. The first infections in the spring are produced by oval shaped one-ciliate zoospores about 2 mu in length which are formed when the resting spores or sporangia germinate. These first infections develop as sori each of which divides to form about five summer sporangia. Within a few days after infection takes place there may be an abnormal enlargement and multiplication of host cells to form a tumor or in highly resistant varieties there may be little enlargement of the host tissues. The summer sporangia germinate by the production of 200-300 oval shaped one-ciliate zoospores about 1.5 mu long. If these zoospores have been mature for two or three days before there is sufficient moisture to cause their release, a large part of them may act as gametes, gametes from different sporangia uniting in pairs to form zygotes. If the zoospores cause new infections such infections develop as sori and produce summer sporangia, but infections produced by zygotes from resting sporangia. Resting sporangia become dark brown, thick walled, more or less globular and 50-70 mu in diameter. These resting sporangia may remain viable for some time but usually germinate as soon after maturity as water is available whether that is within an hour or two or is delayed a week or more. Zoospores from resting spores may begin to disintegrate within a couple of hours or so after the sporangium ruptures if they are unable to infect a host and those from summer sporangia in less than an hour. Either zoospores or zygotes may infect wart tissue as well as normal host tissue. The enormous numbers of sporangia, particularly of resting sporangia, that may be produced during a season, and the ability of the resting sporangia to remain viable for years enable the fungus to survive ordinary crop rotations and cause heavy damage at times in spite of the fact that it is not wind borne, that the zoospores and zygotes which infect the host are able to travel very short distances by their own efforts and are short lived.

(The last paragraph is largely based on the publication by Miss Curtis, (3). See also (5, 7, 8, 9, 10, 13, 14, 22)

Bibliography:

(1) Anonymous

1904-1931 Leaflet No. 105, Board of Agriculture and Fisheries (of Great Britain) was first issued in April, 1904, and has been revised from time to time by the Board and its successor, the Ministry of Agriculture and Fisheries. The leaflet summarizes information regarding potato wart, methods of control, immune varieties, and quarantine measures in the British Isles.

Revision of December 1908.

Although the disease has been known to potato growers in the Liverpool district for some 15 years, it was not reported to the Board until 1901. Also in Wales, Scotland and elsewhere.

Leaflet No. 105, Ministry of Agriculture and Fisheries,
rewritten May 1928.

Wart originally discovered in Upper Hungary (now part of Czechoslovakia) in 1896. May have been in England ten, twenty, or even more years previously. In any case the two earliest British records, made in 1898, show that the disease was already present here then, but those who saw it at that time did not diagnose it correctly. "The first accurate account of Wart Disease published in this country was based on experiments carried out by Professor Potter with material collected in Cheshire in 1900, and is to be found in the Board's (now the Ministry's) Journal for December, 1902." Reported in Scotland in 1907 and in Ireland in 1908. -- Disease found in Austria, Belgium, Czechoslovakia, Denmark, France, Germany, Holland, Norway, Poland, Sweden, and Switzerland in addition to original place in Hungary. Also in Malta, South Africa, New Foundland, Canada, and U. S. p. 2 - 3 Losses due to Wart disease.--It is impossible to estimate with accuracy our present actual losses from this disease. They must be on the whole relatively small..... ".....even under field conditions instances are not unknown where the planting of a susceptible variety in contaminated soil has resulted in practically a total loss of crop." p. 5. Spread of the Disease, of itself, by seed, water, man, animals, dung, etc. - Hosts p. 5 & 6. p. 5 Disease has appeared in a crop grown in land originally contaminated with sporangia, but in which no potatoes had been grown for periods of eight and twelve years. ".....there is apparently at present no instance on record where soil, once well contaminated with the resting sporangia of the Wart Disease fungus, has ever yet become quite free from them and absolutely safe for the renewed planting of a susceptible variety in it." (Also in 1931 edition)

Leaflet No. 105, Oct. 1931 revision.

p. 2 adds Finland, Roumania, Japan to countries infected and

says recent findings in So. America are believed result of introduction from Europe.

p. 6 Solanum villosissimum and S. album, Nicandra physalodes, Solanum chacoense, S. commersonii, S. jamesii, S. nodiflorum, and S. yillosum among hosts listed.

(2) Bell, R. H. and Hartman, R. E.

1939 Potato Wart in Pennsylvania. pp. 1-8, map. Mar. 1, 1939. (mimeographed)

Historical summary of wart, surveys, quarantine and especially treatment work in Pa. Quarantine removed from some areas after annual tests for 5 years showed freedom from wart. "Since the inception of the eradication program in 1934, a total of 3,911 gardens in the 21 treated areas have been planted to susceptible potatoes and not a single new infection has been uncovered." From investigations and observations conclude that soils with temperatures of 60° to 64° F. favor development of wart and with 70° to 72° F. inhibit development. Wart confined to areas with growing seasons of 140 days or less. Without cultivation disease lives in soil 20 years; with fallow or semi-fallow culture without host plants is starved out in 10 years. Expect to eradicate the disease in Pa. by the use of 2,000 pounds of Ammonium Sulfo-Cyanate per acre on generally infected soil and of 2 quarts of Mercuric Chloride (1-1,000) per square foot for small infected spots.

(3) Curtis, K. M.

1921 The life history and cytology of Synchytrium endobioticum (Schilb.) Perc., the cause of wart disease in potato. Phil. Trans. Roy. Soc. London, Ser. B, 210: 409-478. 1921.

An illustrated, detailed study of the organism.

(4) Cuthbertson, W.

1915 Wart Disease of Potatoes. Gard. Chron. 57: 97. Feb. 20, 1915.

Wart said to have been figured and described in Journ. of Hortic. of Dec. 15, 1898, by G. Abkey (in England). Historical and general information, immune vars., etc.

(5) Dix, W. and Kuglmorgen

1932 Untersuchungen über die deimung der Dauersporangien von "Synchytrium endobioticum." (Investigations on the germination of the resting sporangia of Synchytrium endobioticum.) Pflanzenbau, Pflanzenschutz u. Pflanzenzucht 9: 209-16. (Abstr. in R.A.M. 12: 322, 1933).

Potato extract from either susceptible or immune varieties hastens germination. "The highest percentage of germination after four months in this series (82) was obtained in a 6 percent solution of expressed leaf juice of the resistant

variety." The variety was Preussen. Spores ready to germinate at about 5% a month" so that in about two years all would presumably have germinated." Stimulants have no effect after a time, so treated and untreated spores might have the same percentage germinated after 6 mos.

(6) Ducomet, V. and Foex, E.

1928 Essais effectues en 1927 au champ d' experiences etabli par l' Institut des Recherches Agronomiques a Russ-Hersbach (Bas-Rhin) en vue de l'etude de la maladie verruqueuse (Synchytrium endobioticum (Schilb.) Perc.) de la pomme de terre (Trials conducted in 1927 on the experimental field laid out by the Agricultural Res. Inst. etc. for investigation of wart) - Comptes rendus Acad. d' Agric. de France 14: 442-45. 1928. (Abstr. in R.A.M. 7: 596, 1928.)

Wart infection and resistance of potato varieties. - Studies showed infection was transmitted (1) thru the soil to a depth of 50 cm., (2) thru soil of field infected 2 yrs. before, (3) thru sweepings from a cellar where infected potatoes had been stored, even tho disinfected with lime, (4) thru refuse of a village in the infected zone, (5) thru soil of a meadow irrigated with water from infected zone, (6) thru soil adhering to turnips dug from a field infected in the previous year. Air infection spread tests were negative.

(7) Ducomet, V. and Diehl, R.

1936 La galle verruqueuse de la Pomme de terre (Synchytrium endobioticum (Schilb.) Perc.). Mise au point de la question de la resistance des varieties. (A critical summary of the question of varietal resistance.) - Ann. Epiphyt., N. S. i, pp. 57-79, 2 maps, 1936. (Abstract in R.A.M. 15: 601-2. Sept. 1936.)

Notes on introduction into France and present distribution there. "In the north of France new infection centres are due more to the introduction of foreign tubers than to the spread of already existing diseased areas." (R.A.M.) "It appears that under certain conditions favorable to tissue proliferation some reputedly resistant varieties may be very slightly attacked and serve as a source of spread." (R.A.M.) "A study of tuberiferous species of Solanum showed that types susceptible to S. endobioticum are present in all chromosome Groups." (R.A.M.)

(8) Esmarch, F.

1927 Untersuchungen zue Biologie des Kartoffelkrebses. II (Investigations on the biology of the potato wart.) Angew. Bot. 9: 88-124. 1927. (Abstr. in R.A.M. 6: 635-6, 1927 - see also R.A.M. 5: 577-8, 1926 & R.A.M. 3: 477, 1924.)

After-ripening period of resting sporangia varies with conditions. Under favorable conditions most ripen and germinate within a year, a few persisted to $3\frac{1}{2}$ years. Little moisture required for germination. Rain causes more infection than capillary moisture. Limits of sphere of infection are 10 cm. laterally, 10 to 15 cm. upward, 15 to 20 cm. downwards in a vertical direction. "The zoospores are primarily transported toward the tubers by currents of soil water, their own movements being of little significance in this respect. In the early stages of their journey, the motion of the zoospores appears to be without definite direction: only in the immediate vicinity of the tubers is a chemotactic stimulus probably exerted by the susceptible parts."

(9) Glynne, Mary D.

1934 Infectivity of summer sporangia of Potato wart disease in incipient infections on varieties immune in the field. Nature 134: 253, 1934. (Abstr. in R.A.M. 14: 55, Jan. 1935.)

Wart developed in the laboratory on potato varieties apparently immune in field. Infection soon sloughed off. "Inoculations on the susceptible Arran Chief variety from such incipient infections bearing summer sporangia which developed in the laboratory on Snowdrop, Bishop, and Ben Cruachan (apparently immune in the field) gave positive results." (R.A.M.)

(10) Hilli, A.

1932 (The reasons of the spread of potato wart (Synchytrium endobioticum (Schilb.) Perc.) in Finland and abroad.) Valt. Maatabouskoet. Julkais. No. 46. 249 p. 1932. From the English abstract p. 231 - 249:

p. 232. speaking of factors of spread "The most important of these are the transportation and trade of potatoes and the way of cultivation due to the kind of settlement. Other factors of culture (the transportation by soil, manure, fertilizers, animals, people and implements and by the work of eradication of potato wart) are in this respect of greater significance than natural factors (moisture, temperature, light, oxygen, kind of soil, soil reaction, host-plants, parasites). Writer thinks wart as tolerant as potato. Sufficient moisture present in cultivated land to germinate wart spores any time. Resting sporangia endure long drought. p. 233. "On the surface flow of water potato wart can be carried at least 200 metres in cultivated lands just being tilled, as experiments carried out in Pyhajarvi parish in Uusimaa ad. dist. have shown." Wart organism endures cold and heat better than host. Light of little significance. Nature of soil has no great influence. Influence of soil reaction slight. Influence of other hosts slight.

Successfully inoculated Datura inermis, D. metel, Physalis francheti, Solanum atropurpureum, S. marginatum, and S. tuberosum; few sporangia on hosts other than potato. "In Finland (Pusula parish, Hyrkkyla village) it has been possible to ascertain by experiments, that Synchytrium endobioticum resting sporangia retain their viability in meadow land at least 13 years (Tables 1 and 2, p. 28-29). The strength of the infection of the disease has been greater in meadow lands than in such soils which are annually tilled." The table on p. 28 shows 80% contagiousness the 13th year; the table on p. 29 shows 75% contagiousness and 55% contagiousness in cultivated soil 7 years and 8 years after potatoes were grown. p. 234. "In Finland an ordinary 8 year rotation of the cultivation of corn and mowing grass has prevented the disease in ordinary agricultural cultivations." Fertilizers increase wart, resulting in practice of using "fresh" soil from sound fields as fertilizer in Finland. Transporting of wart by human feet mentioned by Sanders (1919) and Neuweiler (1923). "Also in the potato wart areas of Finland the spreading of the disease from one cultivation to another in the earth adhering to footwear has been proved." "It was proved in 1929-1930 on the potato wart infected areas of Hyrkkyla village of Pusula parish, that Synchytrium endobioticum sporangia were preserved in life even over winter on implements plastered with earth."

p. 235. Wart sporangia occur in intestines of earthworms in wart infected areas. Quarantines recommended, Finnish laws require that imported potatoes be grown at least 50 kms. from nearest wart infected areas. (50 kms. almost equal 31 miles) immune vars. - "The cultivation of potato varieties immune to wart disease has considerably affected the extent of spread of potato wart, as this is the most general and reliable eradivative means."

p. 236. Formalin, 10 litres of 10% per sq. metre failed so first infected area in Finland was given 3 litres of 20% unrefined sulphuric acid and copper sulphate 1 kg. pr sq. metre. Apparently successful. Chemical eradication not practicable. Wart found in Finland in 1924 in 5 small areas, in 1925-26 no new areas found, but since 1927 new infected areas have been found each year. "The writer's detailed investigations of the potato areas in Finland made in 1925-1932 have proved however that the disease has reached Finland with three different consignments of potatoes (1893 to Pusula from England, 1929 to Nauvo from Holland and 1929 to Joutseno and Lappi from Germany) and spread from these centres of infection caused by them to the surroundings and even to more distant tracts through the agency of cultural factors." The Holland potatoes are consigned by Messrs.

N. A. V. von Ende & Zoons of the Hague.

p. 237. It is stated that a detailed study of the spread of the disease in Finland, including records of movement of families as shown in church registers of the communities, was made and is given in main text. Some of these noted on pp. 237 & 238. On one estate losses in gardens of workers averaged 30.6% while on the estate fields it was only 5 % due to the 3 to 12 year interval between potato crops on this land.

p. 239. "At the end of 1931 there proved to be potato wart in Finland (Table 46, p. 117) all in 28 villages on the areas of 15 communities. Isolated areas said to be at the time a total of 205, had been in the possession of 163 cultivators. The total area of the tracts infected was 23 hectares 87 ares and the average crop-loss 7.4%."

pp. 239-240. Give some details of infection in different population densities, different soil types, different lengths of time between potato crops.

p. 241. In Sweden at end of 1930, 1725 hectares infected according to information from Thore Lindforss. Norway 48 localities infected.

p. 242. Disease thrives in Faroe Islands where average July temperature is below that of Finnish Lapland. About 6,000 infected cultivations in Denmark at end of 1928 according to Nielsen.

p. 243. 1741 communities in 280 district areas infected in Germany, everywhere about but especially Prussia.

p. 244. "In Holland potato wart occurs (Fig. 12, p. 172) in different parts of the country. In the year 1920 the disease was found in 135 cultivations making a total area of 75.36 hectares. In 1922 the said area was already 410 hectares and it has continued to grow yearly (e.g. in 1928 by 142 hectares)." Chiefly around Winschoten, in northern part of country but also in southern part on banks of river Maas and near Amsterdam. Spread almost exclusively in parts with slight rainfall. - Distributed largely according to density of population.

pp. 245-248. Discussion of situation in various countries especially with reference to correlation of wart and population density. 247 - wart in Poland in area formerly part of Germany. 248 - report for Japan on basis of information given by Pethybridge to writer in 1931. No specific information. p. 249. Believes So. America original home of wart. Fig. 12. Communities in Holland infected with wart disease of potatoes by end of 1927. - Drawn up by the author on particulars presented in literature. 55 numbered and named. (on p. 172.) (Maps of other countries shown also.)

(11) Hintikka, T. J.

1929

Über die Verbreitung des Kartoffelkrebses in verschiedenen Ländern sowie über einige klimatischen Faktoren der ver-seuchten Gebiete. (On the distribution of potato wart in different countries and on some climatic factors of the in-fested areas). Vallion Maataloukoetoiminnan Julkaisuja 23, 102 pp. 11 maps, 1929. (Finnish with Germany summary) (Ab-stract in R.A.M. 12: 50-52. 1933)

Immune vars. listed with countries of origin. Discus-sion of genetics, variability of susceptibility in different countries, etc. Effects of soil, light, moisture, etc.; wet localities seem to favor disease, but in Sweden disease occurs in comparatively dry areas. Coldest European centers of infection in Finland and Sweden lie within isotherms 3° to 4° C., warmest at 20°, south of which point wart occurs only in mountains or in rainy districts.

(12) Hunt, N. Rex, O'Donnell, F. G., and Marshall, Rush P.

1925

Steam and chemical soil disinfection with special refer-ence to potato wart. Journ. Agr. Res. 31: 301-363. Aug. 15, 1925.

This paper gives the results of experiments in treat-ing soil to eliminate wart, by the use of steam alone, of chemicals alone, and of steam and chemicals combined. It also gives the results of studies on soil penetration by steam heat and by chemicals and a discussion of potato growth in chemically treated soil. (Copies of this paper are avail-able.)

(13) Kohler, E.

1931

Weber das Verhalten von Synchytrium endobioticum auf auffalligen und widerstands-fähigen Kartoffelsorten. (On the behavior of Synchytrium endobioticum on susceptible and resistant potato varieties.) Arb. Biol. Reichsanst. für Land - und Forstwirtsch. 19: 263-284, 1931. (Abstr. R.A.M. 11: 69-70. 1932) Author differentiates following grades of infection:

1. All or nearly all sori fail to develop.
2. Most sori abortive, intact ones on upper infected leaves and portions of stem.
3. Most sori intact on upper infected leaves and mid-stem region of full shoots; conspicuous necroses restricted to stem base and lower leaves.
4. Sori predominantly intact; extensive necroses almost all on lower leaves.
5. Necroses barely perceptible, but all or nearly all sori develop completely.

Mode of infection same for susceptible and resistant varieties and number of successful penetrations same. Death of parasite

in resistant varieties result of necrotic processes in host. In severe infection the whole diseased area dies and forms a dark brown layer over infected organ. Growing organs gradually shed this layer. Varieties in grades 1 and 2 are absolutely immune in field, those in 3 to 5 are partly immune and partly susceptible.

- (14) Kohler, E.
1931 Der Kartoffelkrebs und sein Erreger (Synchytrium endobioticum (Schilb.) Perc.) Landw. Jahrb. 74: 729-806. 1931 (Abstr. in R.A.M. 11: 321, 1932.)

This is a complete study of disease and fungus, history, distribution, morphology, biology, hosts, specialization, technique, control, bibliography.

- (15) Kohler, E.
1936 Untersuchungen uber Synchytrium endobioticum (Schlussbericht). (Studies on Synchytrium endobioticum (final report) Z. Pflkrankh., 44: 214-223, 1936.) (Abstr. in R.A.M. 15: 524-5. Ag. 1936).

Successfully inoculated Schizanthus pinnatus, Solanum dulcamara, tomato (Lucullus and Tuckerswood varieties), S. nigrum vars. macrocarpum and chlorocarpum, S. miniatum and vars. viridicaule and rubricaule, and S. racemigerum. Symptoms less marked than in susceptible potatoes.

- (16) Lepik, E.
1935 On the Distribution of the Potato Wart Disease, Synchytrium endobioticum. Phytopathological Experiment of the University of Tartu in Estonia, Bul. No. 28, 1935. (See also Lepik abstract in R.A.M. 13: 799)

Author gives a map showing distribution and sources of infected potatoes (indicated by arrows) but says errors were made in marking the direction of distribution in some cases. "The literary data, which the writer of this article is convinced are wrong, have been left out." This includes some of his own reports in a previous paper (R.A.M. 13: 799). He says there is a difference of opinion as to the source of infection in some cases, Holland disclaiming responsibility for some distribution of wart attributed to her. He seems to think there is ground for argument but commends the Holland service. Claims wart is absent from Estonia, Latvia, Lithuania, and Russia. In Finland, With regard to conflicting reports as to Malta quotes Pethybridge, "With regard to the Island of Malta, I am not able to state with certainty whether Synchytrium endobioticum is still present in that island, but we have official information that in the spring of 1914 a few cases of Wart Disease were observed at Lia and Musta in the variety, Up-to-Date, the seed of which had been imported from England. It was stated that the disease was stamped out immediately and, therefore,

it may not be in the island now. On the other hand, when one remembers how difficult it is to absolutely eradicate a soil parasite like the one in question, it seems quite possible that it may still be in Malta....." Map lists Canada, Newfoundland, U.S.A., Peru, Faroe Islands, Portugal, So. Africa, Malta, and Japan. The map is small and not very clear but has dots indicating infections in the British Isles, France, Switzerland, Germany, Czechoslovakia, Austria, Hungary, Poland, Norway, Sweden, Finland, Holland, Belgium, and perhaps others. Pethybridge, G. H. Fungus and other diseases of crops 1928-1932. Ministry of Agric. and Fisheries, Bul. No. 79, 1934 is only Pethybridge article in literature cited, but quotation cites Pethybridge (1935 in litt.)

(17) Lindfors, T.

1935

Potatiskraftan i Sverige: des utbredning och bekampande intill ar 1935. (Potato wart in Sweden; its distribution and control up to the year 1935) - Medd. Vaxtskyddsanst. Stockh. 11, 1935. (Abstr. R.A.M. 14: 787-8. Dec. 1935.)

Wart distribution in Sweden since discovered in 1912 followed by apparently complete disappearance until 1928, 360 infection centres covering 4,329 hectares. Spread largely by seed potatoes also by manure, domestic animals (esp. poultry), agricultural implements, and running water. Crows and other birds may be involved in spread. Hosts, by inoculations, include Solanum nigrum, S. dulcamara, and Hyoscyamus niger. Wart spores said to have remained viable 13 years in Finland and 10 years in Denmark.

(18) Neumann, H.

1931

Ein Versuchsfeld zur Bekämpfung des Kartoffelkrebses. (An experimental field for the control of potato wart.) Oestr. Zeitschr. für Kartoffelban, 1931, Sondernummer, pp. 115-116. (Abstr. in R.A.M. 11: 321-2. 1932)

Field of 1,000 sq. m. in Austria planted in 1931 to the susceptible var. Alma, harvested Sept. 11. Of 3,000 plants only 35 were free from infection and these appeared to be a different variety. About 200 kg. of potatoes harvested, i.e., approximately the quantity used for seed. Plot believed uniformly infected and well adapted for soil disinfection trials.

(19) Pissareff, V. E. and Vesselovsky, I. A.

1929

Translation of Russian title - Potato selection in the Leningrad region, - Ann. State Inst. of Exper. Agron. Leningrad, 7: 290-300. 1929. (Abstr. R.A.M. 9: 401, 1930.)

Among the medium-early and medium-late varieties, Great Scot was very resistant to virus diseases, late blight, and wart disease (Synchytrium endobioticum), but is not a heavy

cropper in the region; Parnassia was also very resistant to wart disease, but is a poor producer in the neighborhood of Lenin-grad. (From R.A.M. abstract - Later articles in R.A.M. say wart is not in U.S.S.R.)

(20) Selaries, P. & Rohmer, G.

1936 La maladie verruqueuse de la Pomme de terre en Alsace. (Potato wart disease in Alsace.) - Ann. Epiphyt. E. S. i, pp. 23-55, 26 figs., 1936. (Abstr. in R.A.M. 15: 601. Sept. 1936.)

Variety resistance tests show some resistant varieties diseased at times in field. Laboratory infection tests show some vars. resistant in field readily diseased, but infection not apparent. Resting stage produced in lesions on resistant vars. as shown by microscope examination.

(21) Weiss, F., Orton, C. R., and Hartman, R. E.

1923 Investigations of potato wart. U. S. Dept. Agr. Dept. Bul. No. 1156, pp. 1-21. May, 1923.

I. The varietal and species hosts of Synchytrium endobioticum, by Weiss and Orton.

II. The adaptability and use of wart-immune varieties of potato in the quarantined areas of Pennsylvania. By Hartman.

III. The stability of wart immunity, by Weiss.

(22) Weiss, F. and Brierley, P.

1928 Factors of spread and repression in potato wart. U. S. tech. bull. No. 56. March, 1928.

This paper includes proof that apparently healthy potatoes may bear adhering spores and become infected when planted. Agencies of spread distribution of wart spores in surface 8 inches of soil only, duration of infectiousness of soil, tomato hosts, resistance of spores to heat and to seed disinfectants are discussed.

Synchytrium endobioticum

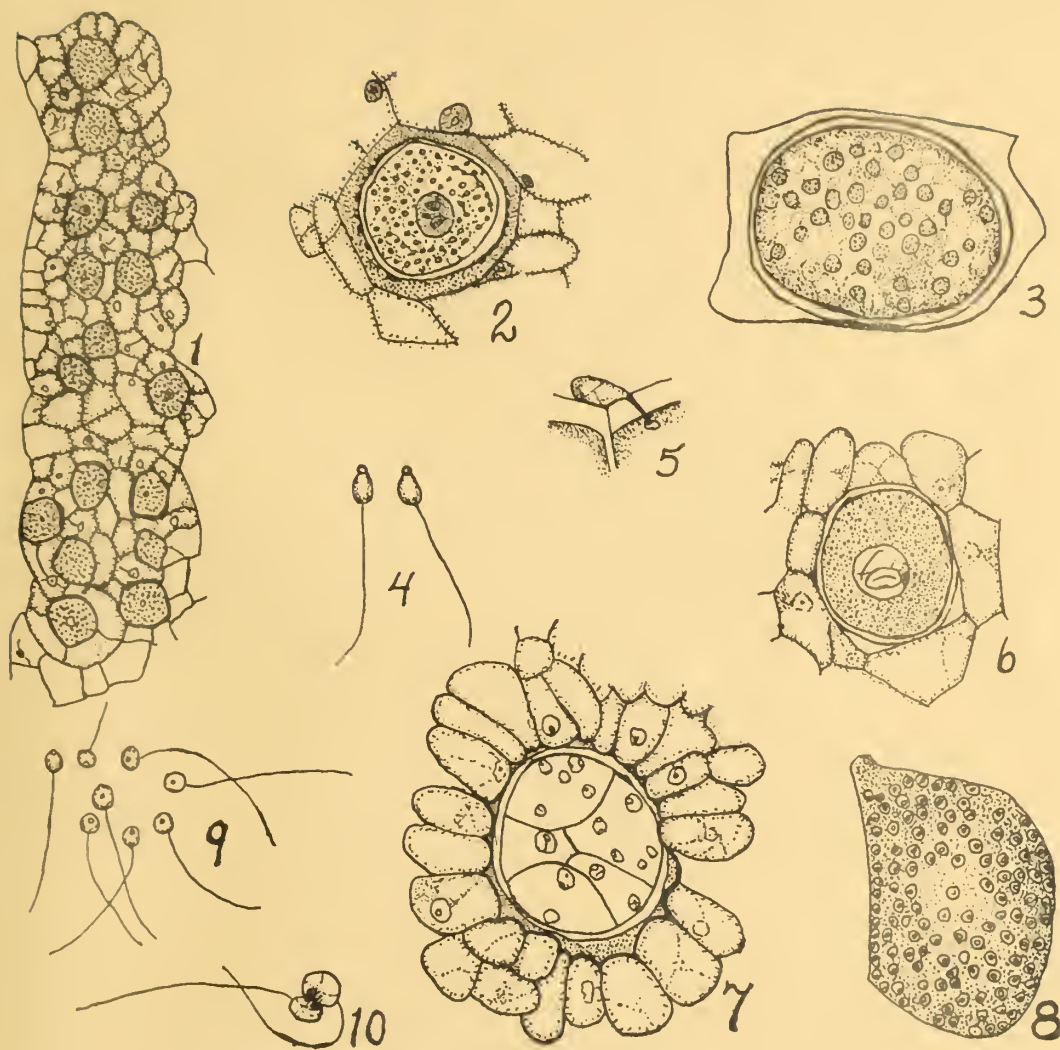
Plate 1



Showing "warts" caused by *S. endobioticum* on stolons of Bliss Triumph (at left) and on a Netted Gem tuber (at right). The size of the warts produced varies with varieties and conditions. Bliss Triumph tends to produce small warts on tubers, larger ones on stolons.

(From U.S.D.A. Department Bull. No. 1156. May, 1923. Plate III)

Synchytrium endobioticum
Plate 2



1. Resting sporangia developing in wart tissue. 2. Resting sporangium in tissue. 3. Resting sporangium with zoospores forming in it. 4. Zoospore from resting sporangium. 5. Zoospore entering a host cell. 6. Nearing the end of the prosorus stage. 7. A sorus showing 5 summer sporangia. 8. Summer sporangium nearly ready to discharge zoospores. 9. Zoospores from summer sporangium. 10. Zoospores acting as gametes uniting to form a zygote.

(After Miss K. M. Curtis, in Roy. Soc. London, Phil. Trans., Ser. B. 210: 409-478. Pls. 12-16. Jan. 14, 1921.)

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